Poverty and Obesity in the Developed World

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Abstract:

In the past three decades worldwide obesity rates have skyrocketed, contributing to a myriad of health problems in the affected regions. We have tested for the effects of various factors on obesity, primarily the effect of poverty on obesity rates. At first we used a single regression model to compare country GDP and average population BMI in 162 different countries with the assumption that the two will be positively correlated. Next we focused on the developed world to draw conclusions about the correlations between obesity, poverty, and factors such as education levels using a single and multiple regression model. We found significance between per capita income and prevalence of obesity in the United States in our single regression model at the 10% level but were unable to find meaningful data correlation in our multiple regression; however, we did find a very significant negative impact of high school graduation rates on obesity rates and a positive correlation between the percentage of non-Hispanic white population and obesity rates by state.

Keywords: Obesity, GDP, Income, Econometrics, Regression

I. Introduction

BMI (Body Mass Index) is a crude population measure of obesity measured by dividing a person's weight by the square of their height. A BMI of 30 or more is considered obese, and a BMI of 25 or greater is considered overweight.

It is no secret that worldwide increases in obesity rates coincide with adverse health outcomes. As average population BMI rises so too does the prevalence of diseases and disorders like diabetes, cardiovascular diseases, and various types of cancer. Obesity thus contributes to some of the leading causes of preventable death. In 2010 obesity and overweight were estimated to be the leading cause of at least 3.4 million deaths worldwide. The rise in obesity-related mortality rates has also contributed to a rise in overall medical expenditures, placing a growing financial burden on health services and the economy overall. In the United States alone the estimated medical cost of obesity was $147 billion in 2008. The medical costs of obese individuals were approximately $1,429 higher than those of normal weight on an annualized basis. Because of both the economic burden as well as the health consequences associated, obesity is almost universally viewed as a very large problem facing the world today.

There is a general consensus that increasingly easy access to calorically dense and nutrient poor food has been a large factor in the rising rates of obesity in the developed world and countries with a higher GDP. Cheap, high calorie foods have become a less expensive and sometimes easier alternative to cooking healthy meals thanks to the rise and proliferation of fast food throughout the developed world. Because of this we conjecture that due to the relatively high cost of healthy living, there will be a correlation between poverty and obesity rates in the developed world. We use data from the United States circa 2010 to illustrate this.

In countries where there is not such easy access to calorically dense foods or even food in general we assume there will be an opposite trend in obesity rates. We hypothesize that in these poorer countries there will be a generally lower BMI as compared with countries with larger GDP. This rationale provides the basis for our first regression model which compares country GDP to overall average BMI.

We hypothesize and have found that higher BMI and GDP are generally correlated worldwide. We also hypothesize that there will be a negative correlation between income rates and the prevalence of obesity in the United States by state. In this case we found significance of per capita income on prevalence of obesity by state on the 10% level in our single regression model but not in our multiple. Education and racial demographic data also appears to play a significant role in obesity prevalence in the United States. Our research uncovered significant data to demonstrate a negative correlation between high school graduation rates and prevalence of obesity as well as a positive correlation between percent non-

Hispanic white population and prevalence of obesity. All of the measures for the United States were by state.

II Literature Review:

The subject being addressed in this paper and in those being reviewed is, very generally, obesity and its various causes. Other than obesity itself, we found that socioeconomic status was one of the only common themes between the works we reviewed. All works are in agreement that obesity is a growing issue worldwide, but each work points to different factors and causes of the issue and suggests different courses of action to aid in the fight against obesity.

Hojja, T. (2013) gives a good overview of the obesity epidemic both in the United States and in the rest of the world. The paper discusses some causes of obesity and stresses the effect of relatively low cost, energy dense foods on rising obesity rates. Hojja suggests a change in health policy in order to stem these effects. The paper spends considerable time describing the economic burden of obesity as well as various health consequences. Hojja acknowledges that there is an increasing understanding of the causes and consequences of overweight and obesity within the population but strongly advocates the development of a comprehensive strategy and food policy to help stem the increase of obesity and of obesity-related costs.

Egger et al. (2012) examines the relationship between the wealth of a country measured in terms of GDP, the prevalence of obesity measured in terms of BMI, and other factors such as happiness and environmental impacts, like carbon emissions. The goal of this study was to find a particular level of GDP which would maximize the levels of the other aforementioned factors. This study implies that a large cause of the growing obesity problem in developed countries is that the goal of modern, market-based economies is economic growth, which means a continuous increase in consumption of all kinds, including food. Consumption-based growth often results in over-consumption, and over-consumption of food often results in obesity. This study insists that due to the diminishing returns of economic growth, there may be an acceptably high GDP level to stop growing and optimize national health. This study also indicates that there is a large connection between body weight and personal stability and security. A higher BMI is associated with those who suffer from wealth, health and employment insecurity. These three main types of insecurities, the paper asserts, are most strongly correlated with market-liberal economies since the competition they encourage can negatively affect personal stability. The study heavily implies that wealthy countries with high income inequality tend to have a higher average BMI than countries with lower income inequality.

Pickett (2005) looked to find a correlation between income gaps and body weight among developed countries. Pickett et al. state that while in the past a higher body weight was associated with wealth and a lower weight with poverty, obesity is currently associated with the reverse. In addition to the oft-quoted factors like prevalence of low cost, high calorie foods, this study cites psychosocial stress as a major reason behind this socioeconomic difference in obesity rates. The study asserts that the increased level of this stress on the lower class has a significant impact on their heightened obesity rates. Pickett et al. collected and analyzed data from 21 of the top 50 countries with the highest GDP per capita in order to support the correlation between income inequality and obesity.

Skinner et al. (2014), using data of children ages 2 to 19 years in repeated cross-sections of the National Health and Nutrition Examination Survey from 1999 to 2012 of children in the United States, found that although childhood obesity rates have stabilized there has been a significant increase in the severity of obesity in children. This increase in the levels of obesity among children does not bode well for the health of the future adult population. The article also states that more research is needed to find what, if any, government or public health interventions is causing the stabilization of childhood obesity rates and to find the causes of the increase in severe obesity.

There is a consensus that excessive caloric intake over an extended period of time causes obesity, but there are many different drivers of this excess. These drivers differ by region, and we hypothesize that we will find opposite correlations between our chosen driver (poverty) throughout the world versus in developed, wealthy nations. To test our hypothesis we attempted to model obesity trends in a developed nation (the United States) and to create a more basic model to demonstrate a trend worldwide. To do so we use two single and one multiple OLS regression model. We find relatively robust data to support the hypothesized correlation between higher BMI and GDP worldwide, but did not find enough significance to support the hypothesis that poverty and obesity are negatively correlated in the United States (a developed nation).

III. Data

This study focuses on worldwide and national trends in Obesity. Worldwide, the study focuses on the impact of a country's GDP on their average BMI. Nationally, the study focuses on the impact of each state's per capita income on their average BMI.

3.1 single regression

Through our first model we were seeking whether or not GDP has an effect on average country BMI in order to find whether or not the data supports our hypothesis that these two are positively correlated. Our model is listed below.

$$BMI = \beta_0 + \beta_1 GDP + u$$

Based on the following table we can conclude that GDP per capita is significant at all levels.

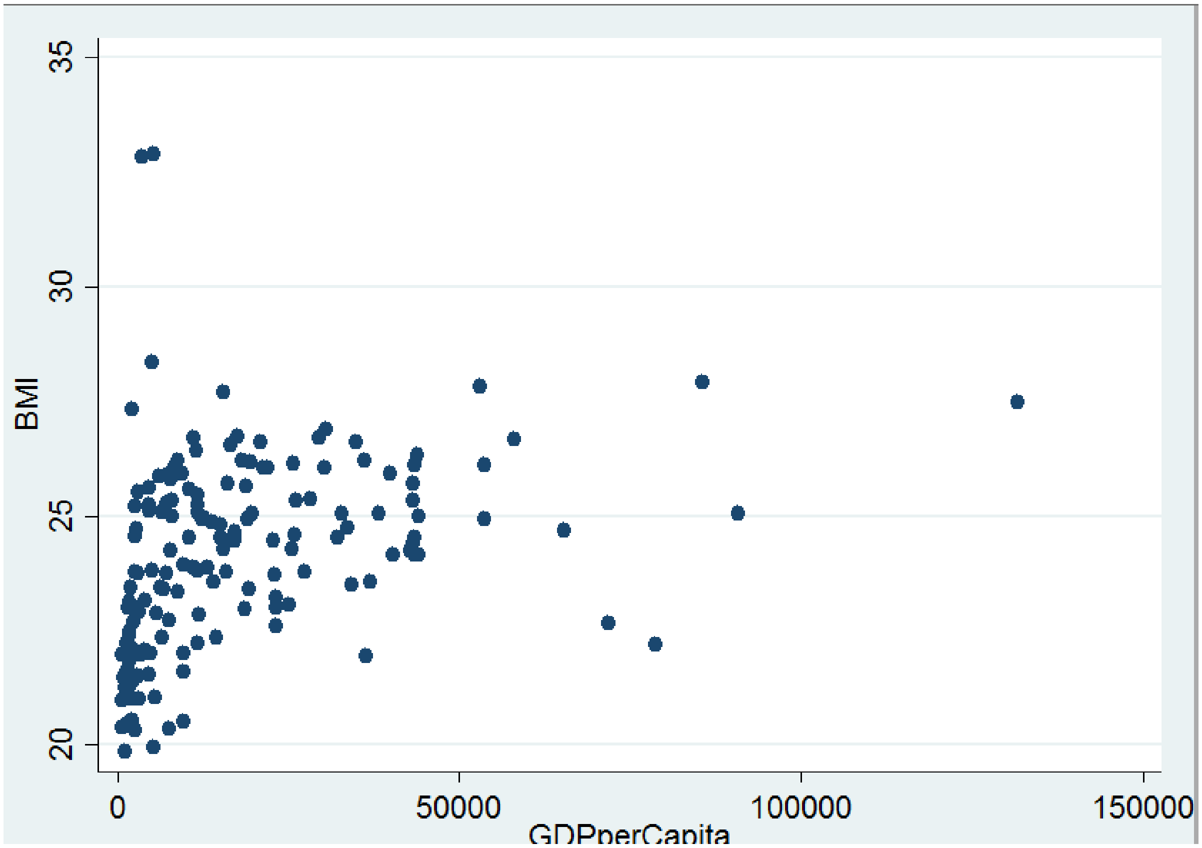
GDP per Capita vs BMI

Source	SS	df	MS
Model	90.2291901	1	90.2291901
Residual	652.868554	160	4.08042846
Total	743.097744	161	4.61551394

Number of obs	=	162
F(1, 160)	=	22.11
Prob > F	=	0.0000
R-squared	=	0.1214
Adj R-squared	=	0.1159
Root MSE	=	2.02

BMI	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
GDPperCapita	.0000375	7.97e-06	4.70	0.000	.0000217	.0000532
_cons	23.43092	.212843	110.09	0.000	23.01058	23.85126

The dependent variable in this case is average country BMI with GDP as our independent variable. We chose this independent variable to test the correlation between larger GDP and higher average BMI. We used data of average BMI by country from the World Health Organization and data for country GDP from the World Bank. We were able to find data points for 162 of the 196 countries in the world with BMI being the restriction in this case. Our data scatter is pictured below:



We found a generally positive correlation between average country BMI and GDP.

3.2 Second Single Regression

Our second regression follows the previous in regards to the impact of income/poverty on obesity. Through this model we are trying to find out whether or not state per capita income has an effect on the prevalence of obesity. We utilized this regression in order to find whether or not the data supports our hypothesis that these two factors are negatively correlated.

The dependent variable in this case is the prevalence of obesity by state, with state per capita income as our independent variable. We chose this independent variable to test the existence of a negative correlation between larger income and a greater prevalence of obesity. We used data of obesity prevalence by state from the CDC and data for state per capita income from the United States Census Bureau. We were able to find data points for all 50 states in the United States, plus the District of Columbia.

Table 1

Source	SS	df	MS		
				Number of obs =	51
				F(1, 49) =	3.99
Model	44.3861084	1	44.3861084	Prob > F =	0.0514
Residual	545.601343	49	11.1347213	R-squared =	0.0752
				Adj R-squared =	0.0564
Total	589.987451	50	11.799749	Root MSE =	3.3369

PrevObesity	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CapitaIncome	-.0002041	.0001022	-2.00	0.051	-.0004096	1.33e-06
_cons	34.34459	2.889727	11.89	0.000	28.53747	40.15171

Based on Table 1 we found that *CapitaIncome* is significant only at the 10% level, which shows that there is an impact of per capita income on obesity prevalence. We did not believe that this was significant enough to draw any sort of conclusion about a correlation between the two.

3.3 Multiple Regression

For our multiple regression model we chose to focus on a single country: the United States. This model looks at the impact of per capita income, age, high school graduation rate, health-care spending, and percentage of non-Hispanic whites on the prevalence of obesity by state. Data for average income level, age, percent of population that had graduated high school, and percentage of the population that are non-Hispanic white came from the United States Census Bureau. This data is from the last census taken in 2010. The data for the prevalence of obesity by state is from the CDC, and the information on healthcare spending by state is from the Henry J. Kaiser Family Foundation, an organization dedicated to finding information on health issues.

Table 2

Source	SS	df	MS
Model	298.477216	5	59.6954433
Residual	291.510235	45	6.47800521
Total	589.987451	50	11.799749

Number of obs	=	51
F(5, 45)	=	9.22
Prob > F	=	0.0000
R-squared	=	0.5059
Adj R-squared	=	0.4510
Root MSE	=	2.5452

PrevObesity	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
CapitaIncome	-.0000974	.0000811	-1.20	0.236	-.0002606	.0000659
Age	.0096907	.2090841	0.05	0.963	-.4114263	.4308077
HighSchool	-67.24224	13.01327	-5.17	0.000	-93.45231	-41.03218
HealthSpend	-8.14e-06	.0004342	-0.02	0.985	-.0008826	.0008663
PercWhite	.1231913	.0271512	4.54	0.000	.0685059	.1778767
_cons	80.79419	11.59884	6.97	0.000	57.43293	104.1555

We chose our first independent variable, average income level, based on our hypothesis that it would be negatively correlated with obesity prevalence. Age was chosen as an explanatory variable based on the assumptions that, generally, as people age their lifestyles become more sedentary. High school graduation rate was a relatively intuitive choice based on the idea that a better educated population would make smarter nutrition decisions. Healthcare spending was an obvious choice due to the general increase in the cost of obesity related diseases and ailments, and percentage non-Hispanic white population was used to determine cultural effects on obesity. The following table summarizes the data by showing the number of observations, mean, standard deviation, and the minimum and maximum data points of each variable considered.

Variable	Obs	Mean	Std. Dev.	Min	Max
State	0				
PrevObesity	51	28.65098	3.435076	21.3	35.1
CapitaIncome	51	27893.98	4615.953	20670	45004
Age	51	36.70588	2.19412	28	40.7
HighSchool	51	.8690196	.0338381	.8	.92
HealthSpend	51	7036.667	1041.712	5031	10349
PercWhite	51	70.69608	16.12752	22.7	94.4

Table 3.

Before results were obtained, the Gauss-Markov assumptions for linear regression were verified. The assumption of linearity of parameters holds, as can be seen in the results. The assumption of random sampling is satisfied as the data sources we used, the CDC and the United States Census Bureau, collect their data through random sampling . As can be seen in the Table 4, the independent and dependent variables are not perfectly collinear, and as such, do not violate the Gauss-Markov Theorem.

Table 4.

	PrevOb~y	Capita~e	Age	HighSc~l	Health~d	PercWh~e
PrevObesity	1.0000					
CapitaIncome	-0.2743	1.0000				
Age	0.0561	0.0323	1.0000			
HighSchool	-0.4519	0.2642	0.2495	1.0000		
HealthSpend	-0.2097	0.1120	0.5040	0.3489	1.0000	
PercWhite	0.2936	0.0546	0.3816	0.4225	0.0612	1.0000

IV. Results

Table 5

Dependent Variable: Average BMI			
Independent Variables	**Single variable Regression**	**Multivariable Regression**	**Restricted Multivariable Regression**
kk	-.00020* (.00010)	-0.000097 (.000081)	
Age		.0097 (.209)	
Percentage of Highschool Graduates		-67.24 (13.013)	-71.17*** (11.54)
Health Expenditure		-8.14e-6 (.00043)	
Percentage Non-Hispanic White		-.12*** (.027)	.12*** (5.19)
Intercept	34.34*** (2.89)	80.79*** (11.59)	81.62*** (9.44)
No. of obs.	51	51	51
Adjusted R-squared	.056	0.451	0.46

*, **, and *** indicate significance at the 10%, 5% and 1% level, respectively.

To test our hypothesis we constructed both simple and multiple regression models. We first constructed a simple regression model over countries worldwide in order to show that developed countries, those with a higher GDP per capita, would also have a higher average BMI. After we determined that our original hypothesis was correct, we conducted a simple regression on one developed country, the United States, in order to test our hypothesis that in developed countries obesity and income per capita have a negative correlation.

STATA was first used to conduct a simple regression between GDP and income per capita. The resulting correlation was:

PrevObesity = 34.34 -.00020(CapitaIncome)

As seen in the table, for the single regression model of BMI and income per capita, with a p-value of .051, the coefficient obtained was statistically significant, but only at the 10% level. The independent variable of income per capita has a coefficient of -.00020; this shows that our original hypothesis that BMI and income per capita would have a negative correlation tended towards validity. It was also close to being significant at the 5% level, but since 5.1 > 5>1, the independent variable in this simple regression model is only statistically significant at the 10% level.

STATA was then used to conduct a multiple regression model as follows:

*PrevObesity = 80.79 - .000097(CapitaIncome) + .0097*Age - .6724(Highschool) - 8.14e-6(HealthSpend) + .12(PercWhite)*

Following this, our second model included average age, percentage of high school graduates, health expenditure, and percentage of the non-Hispanic white population. With p-values of .236, .963, and .985 respectively, income per capita, age and health care expenditure were shown not to be statistically significant. All three of these aforementioned p-values are far greater than .10, .05, and .01, and as such they are statistically insignificant at the 10%, 5%, and 1% levels., However, the percentage of high school graduates and the percentage of non-Hispanic white population were shown to be statistically significant at the 1%, 5%, and 10% levels as both independent variables had a p-value of 0.

Since the income per capita, the average age of the population and the health care expenditure were shown to be statistically insignificant at the 1%, 5%, and 10% levels, we then did a regression without these three variables. The third regression model listed reflects the restricted regression model, which removed the aforementioned variables. A robustness test to assess joint significance was then performed using the restricted and unrestricted models. After using the f-statistic test, the three removed variables were shown to also be jointly insignificant: the f-value obtained was .436, which does not exceed the f-value needed to be statistically significant.

F = [(SSR_r) - (SSR_{ur})]/q÷ [(SSR_{ur}) /(n-k-1)] = [(300)-(291.51)]/3÷[((291.51)/45]

F = .436

Therefore, the model that best predicts obesity rates would be the restricted multivariable regression model. The independent variables that were removed were found to also be jointly insignificant, thus we can use a model that does not include these variables at all. It is important to test for joint significance because if the variables were found to be significant together, then they would still be important for the model.

IV. Conclusions

Obesity and overweight has been a growing problem throughout the world in the past few decades. Because of this increase in obesity and its related consequences there has been a concerted effort to study and find ways to stop this trend. This paper sought to add to the existing bulk of knowledge to that end with a focus on the effects of poverty on obesity and an increased BMI. We hypothesized that on a global scale GDP and BMI would be positively correlated due to poorer countries having a larger malnourished population. On a countrywide level we hypothesized that in a developed country lower incomes would be correlated to a raised BMI. We used the United States as our developed country to research due to its high prevalence of obese and overweight individuals and tested the impact of per capita income statewide on the prevalence of obesity in each state. Our worldwide data regression yielded a general positive correlation between BMI and GDP. On a countrywide scale, however, we found that *CapitaIncome* was only significant in our single regression at 10%, and was not significant at any level in our multiple regression.

The lack of significance of *CapitaIncome* on *PrevObesity* in our multiple regression model led us to further investigate the other independent variables in our multiple regression. In doing so we found that the percentage of high school graduates in a state as well as the non-hispanic white population were significant at the 10%, 5%, and 1% level. *Highschool* had a negative impact on the prevalence of obesity while *percwhite* had a positive impact. We believe that the lack of significance of *CapIncome* on *PrevObesity* has to do with the similar level of access to food throughout all income levels in the United States. Generally low cost foods in the United States are more calorically dense while being less nutrient rich (McDonalds and other fast food) leading the poorer population to rely on these food sources, while the richer population is free to overeat more varied food types.

In the future we believe it would be beneficial to further investigate the effects of *Highschool* as well as *percwhite* on *PrevObesity* and other obesity related ailments such as heart disease and type II diabetes. Our data leads us to hypothesize that these independent variables will be significant on a county and possibly citywide level which may be useful in finding trends by region and finding which areas are more sensitive to these variables.

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